Seismic Analysis of RC Building Resting on Sloping Ground: A Review

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Abstract- *In hilly areas buildings are built on sloping grounds. When the hilly areas come under the seismic zones, these buildings are highly vulnerable to earthquakes. This is due to the fact that the columns in the ground storey are of different heights in such a way that column in one end is a short column and column in other end is a long column. Dynamic characteristics of hill buildings are somewhat different than the buildings on flat ground. Torsional effect of such buildings is damaged for having the difference stiffness and mass along horizontal and vertical plane during ground motion.*

Keywords- Seismic Analysis, Sloping ground, base shear, Displacement etc.

I. INTRODUCTION

The term Earth quake define as the natural or manmade unstable waves which comes on the surface of earth make hazards. results to loss of property and human lives. Seismic waves are caused ordinarily by crack of geologic Faults. The frequency, sort and magnitude of earthquakes fully fledged over an amount of your time outline the seismic activity of that space. The observations from a seismometer wont to measure earthquake, Earthquakes larger than some five are principally reportable on the size of moment magnitude. Those smaller than magnitude five, that are additional in variety, as reportable by the national geophysical science observatories are principally measured on the native magnitude scale, that is additionally referred to as the scale
In 21st century because of increasing density population, the no. of ranges in units is diminishing step by step. At present time the strategies for seismic assessment for the seismic harm or quake harmed structures are definitely not however completely created. The structures which don't satisfy the prerequisites of seismic plan, may endure broad harm or then again breakdown whenever shaken by a serious ground movement or quake. Tremor is the significant explanation behind the issue of security for the development of multi story structures. The structures which are available currently are planned and built by according to more seasoned code arrangements, are not fulfilling. Hence it is have to develop various sorts of structures which have the ability to oppose the powers, similar to Flat Slab what's more, R.C Framed structure structures are increasingly appropriate for the present a day, in view of expanded in populace and the land esteem.

II. SEISMIC BEHAVIOR OF BUILDING ON SLOPE

Most of hilly regions in northern India where seismic activities are common, buildings are required to be constructed on sloping ground due to scarcity of plain land. In hilly regions, engineered construction is constrained by local topography resulting in the adoption of either a step back or step back & set back configuration as a structural form for buildings. Sloping ground and leveled ground, by using response spectrum method. Buildings in hilly regions have experienced high degree of damage leading to collapse though they have been designed for safety of the occupants against natural hazards.

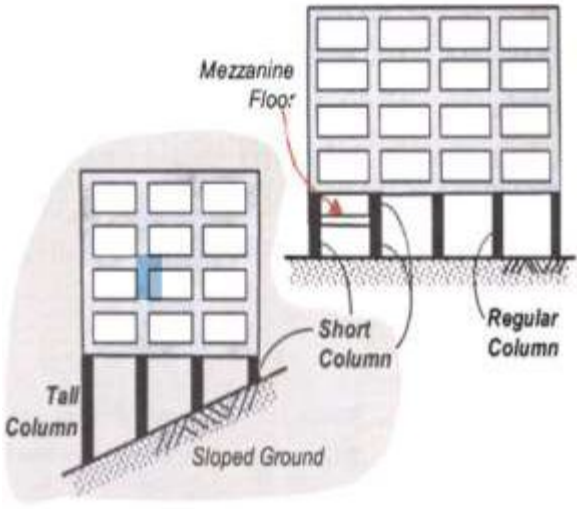

Fig: 1.1 sloping ground

III. LITERATURE REVIEW

Shivakumar Ganapati et al (2017) they considered model consist of 3 bays with 10 story building, each bay having a dimension of 5m in X direction 5m in Y direction. The story height is kept 3m .the beam size is of 0.3x0.45m and the

column size is of 0.6x0.85m.The slab thickness is 0.125m. The building is to be situated in the seismic zone 5 with medium soil.They observed that in step back-set back building on sloping ground maximum displacement decreases when compared to step back building on sloping ground without floating column. Hence they concluded that that building with provision of floating column at corner on any floor shows the poor performance compared to other cases. Hence provision of floating columns at corner should be considered as critical case, hence special attention is needed.

Ravindra Navale et al (2017) Studied on Following types of structures are analyse as lateral load resisting frame. Column sections of size 230mm×600mm, beam sections of size load, floors finished load 1 KN/m2, live load 2 KN/m2 on all floors earthquake loads as per IS 1893:2002. The damped and un-damped frames with different geometrical configurations viz. are taken for the study. Model-1 building on normal terrain Model-2 building on sloping terrain For the seismic analysis of building, the zone factor 'Z' is taken as 0.24 for seismic zone IV, Importance Factor 'I' equal to 1. They observed that bending moment in sloping terrain building is reduces considerable, but tremendously increase at base of building. Hence they concluded that Seismic Performance of building can be improved by providing step up set back columns, which resist input energy during earthquake.

Naveen Kumar S M et al (2017) They structures are generally constructed on level ground; however, due to scarcity of level grounds the construction activities have been started on sloping grounds. There are two types of configuration of building on sloping ground, the one is step back and the other is step back setback. In this study, G+ 10 storeys RCC building have been considered for the analysis. A comparison has been made with the building resting on level ground. The modeling and analysis of the building has been done by using structure analysis tool ETAB 2015. The seismic analysis was done by the response spectrum analyses have been carried out as per IS: 1893 (part 1): 2002. The results were obtained in the form of top storey displacement, Storey drift, Base shear and over turning moment. They observed that the Overturning moment is same till story 4 because column height is same , but after story 4 it overturns due to column variation and also overturning moment gradually decreases for step back configuration on sloping ground compare to step back on flat ground for load. Hence they concluded that Base shear is more for sloping strata than plain strata for both D-con 7 and D-con 9 combinations and the over turning moment gradually decreases on sloping ground than compare to flat ground in both D-con 7 and D-con 9.

Vrushali et. al. (2015) Studied the effect of earthquake on high rise building (G+15) resting on sloping ground using STAAD.Pro software for structural analysis and design, same loading conditions are considered in each case and comparative study is done considering different sloping angels as (0o, 7.5o, 15o& 22o) and observed that Buildings resting on sloping ground have more lateral displacement compared to buildings on plain ground, the critical bending moments is increased on 22° slope than 7.5° slope and 15° slope ground and after designing, it is concluded that steel quantity on sloping ground is more than on plain ground for same cross section of column and beam.

Prasad Ramesh Vaidya et al (2015) This study investigates the to understand the behaviour of the building on sloping ground for various positions of shear walls and to study the effectiveness of shear wall on sloping ground. The performance of building has been studied with the help of four mathematical models. Model one is of frame type structural system and other three models are of dual type (shear wall-frame interaction) structural system with three different positions of shear walls. Response spectrum analysis is carried out by using finite element software SAP 2000. The performance of building with respect to displacement, story drift and maximum forces in columns has been presented in this paper.

S. K. Deshmukh, Farooq. I. Chavan (2015); The aim of study is to analyze the RCC building sloping ground ,as such building are different from those in plains, they are irregular variation along the vertical and horizontal planes. The Experimental method used over here for seismic analysis is linear static method for seismic analysis of G+6 storey plain building as well as inclined building. In these case the analysis of structure is carried out computationally by using STAAD.Pro Initially plain they are very irregular and unsymmetrical in horizontal and vertical planes and subjected to torsion and twisting forces, this leads to, severe damage when subjected by Earthquake ground motion due to mass and stiffness building G+6 storey with plan dimension of 20m x 9m has been analyzed which is later on compared with analysis of similar building resting on sloping ground.

A. S. Swathi et al. (2015); Studied on in hilly areas buildings are built on sloping grounds. When the hilly areas come under the seismic zones, these buildings are highly vulnerable to earthquakes. This is due to the fact that the columns in the ground storey are of different heights in such a way that column in one end is a short column and column in other end is a long column. Along with this if the building has an open ground storey, the seismic vulnerability is further increases. This paper deals with the comparison of seismic performance

of soft storey building on sloping grounds and soft storey building retrofitted with shear wall. The aim of the paper is to check if the seismic performance of the structure is improved when it is retrofitted with shear wall.

Narayan Kalsulkar, Satish Rathod (2015) generally, building frames are analyzed for gravity loads in vertical direction and lateral loads like earthquake load and wind load in lateral direction. The analysis of structure depends on idealization of geometry of structure and idealization of load system on the structure. The behavior of buildings during earthquake depends upon the distribution of mass and stiffness in both horizontal and vertical planes of the buildings. General behavior is shattered when the structure has irregularities. These kinds of irregularities are especially seen in hilly regions, where the structure rests on the sloping ground. In the present study, the response spectrum method is carried out on the type of structure that rests on the sloping ground. Building frames which occurs in hilly regions are narrowed down to two basic formats such as step back frames and step back-set back frames and dynamic responses have been studied for various building configuration.

R. B. Khadiranaikar and Arif Masali (2014) The dynamic response of the structure on hill slope has been discussed. A review of studies on the seismic behaviour of buildings resting on sloping ground has been presented. It is observed that the seismic behaviour of buildings on sloping ground differ from other buildings. The various floors of such buildings step backs towards hill slope and at the same time buildings may have setbacks also. Most of the studies agree that the buildings resting on sloping ground has higher displacement and base shear compared to buildings resting on plain ground and the shorter column attracts more forces and undergo damage when subjected to earthquake. Step back building could prove more vulnerable to seismic excitation.

Sujit kumar et. al. (2014) observed the behavior of sloping ground structures considering inclinations of (7.5o, 15o) under seismic forces. Considering seismic zones comparison has been done on sloping ground and plane ground building. Here G+ 4 storeys are taken with same properties and loadings for its conduct and comparison. Observed that bending moment in column increases with increase in sloping angle of the ground whereas axial force in columns remains almost same.

Aslam hussain et. al. (2014) presented a comparative study on effect of different wind velocity on different sloping ground (0 o,5 o,10 o & 15 o degrees) using STAAD.Pro software for modeling 2-d frame and analysis. And observed Maximum bending moment in beams for different building heights increases with increase in the wind velocity whereas minute change in moment on beam due to slope change, and Max moments in column increases with increase in the wind velocity as well as ground slope.

P. M. Mohite et. Al, (2014) presented a comparative study of G+6 storey structure in hard strata with different ground slopes of 26°,28°,30° and considering seismic zone III using analysis software STAAD.Pro and observed Top storey displacement of building resting on plain ground is less than that of building resting on sloped ground, Top storey displacement of setback stepback building is less than that of step back building and Use of bottom ties gives effective response of hilly building.

G Suresh et. Al, (2014) studied dynamic analysis of a 3-dimensional frame using response spectra method in which comparative study has been done on stepback and step back set back buildings on a sloping ground and observed the fundamental time period, storey displacement, base shear and concluded that step back set back buildings are more suitable in sloping ground.

S. Pradeepet. Al, (2014) studied the G+2 model with same loading and properties in a hard soil considering seismic analysis according to IS 1893 (Part 1): 2002 to determine either short column or long column will attract larger Earthquake forces using MS Excel, STAAD.Pro and ANSYS and observed that The short column is stiffer as compared to the tall column, and it attracts more seismic forces and observed that in displacement as the column on sloped ground shows very less displacement while compare to the column on plane ground.

Hemal J shah et. Al, (2014) presented a comparative study of plain ground and sloping ground of 23 degree and 27 degree slope are considered with same loading conditions and properties for 5 storey and 10 storey in medium soil and seismic zone is taken as zone V structure dynamic analysis has been done using SAP2000 and it is observed that the building on 23 degree slope has lowest time period so it is more rigid building and gives higher earthquake forces.

Kalyanrao et. Al, (2014) studied sloping ground structure subjected to seismic load as assessed in ATC40 and FEMA356. Here pushover analysis is done using analyzing software ETABS in which three cases of ground is considered asset-back, step-back or step-back setback to study the behavior of structures during earthquake relies on the dissemination of mass and solidness in both planes and it is concluded that the maximum base shear is induced in Set-back-Step-back structure. here base shear got by "pushover analysis" builds the execution indicate as thought about the

configuration base shear and it is finished up that Step-back-Set-back structure may be favored on sloping ground which increases the performance.

Pradeep Kumar Ramancharlaet. Al,(2013) observed the behavior of a building on varying sloping angles i.e. 15degree, 30 degree**,** 45 degree and 60 degree is studied using shear wall in different location and contrasted and the same on the level ground. structure is analyzed as per IS 456 and subjected to earthquake loads .It was observed that as the slope angle is increasing, building is becoming stiffer. Two types of analyses were conducted viz., lateral load analysis and incremental dynamic analysis. It was observed from the initial results that the columns on the higher side of the slope i.e., short columns were subjected to more shear force then longer columns on the lower side.

Agrawal et al. (2011) presented a comparative study of different wind characteristics pertaining to dynamic wind load for three terrain categories namely: suburban, heavy sub-urban and urban as given in different international wind codes and standards. The different codes used in his study include Japanese, Australia, New- Zealand, American, British, European,Canadian, Hong-Kong, Chinese and Indian [existing (1987) as well as proposed (2011)]. The differences in various codes standards for the above parameters have been discussed with reasons.

Bakhshi et al. (2011) observed that the structure with lower height or number of stories in which parameters dominant in seismic loading and with increasing in height of buildings, rate of influence of wind load along the height is larger than seismic loading and the results of wind and earthquake characteristics was compared in the form of power spectral density (PSD). Dynamic wind force in not constant along the height but also it becomes larger and more intense with increasing height. In his research the effect of dynamic time history wind load is considered and when it's applied along the height of tall buildings, the fluctuating wind speed is simulated as an ergodic multivariate stochastic process, and the Fast Fourier Transform is needed to estimate the fluctuating wind speed components acting on the structure. Peak drift and displacement are two important parameters for comfort criteria that affect human perception to motion in the low frequency range of 0-1 Hz encountered in tall buildings.

Chandrasekaran and Rao (2002) investigated analysis and the design of multi- storied RCC buildings for seismicity. Reinforced concrete multi-storied buildings are very complex to model as structural systems for analysis. Usually, they are modeled as two-dimensional or three-dimensional frame systems are in plane and slope with different angles 5o, 10o, and 15o. Analyze multistoried buildings in the country for seismic forces and comparing the axial force, shear force, moment, nodal displacement, stress in beam and support reaction compared too current version of the IS:1893– 2002 to the last version IS:1893-1984.

IV. CONCLUSION

Till now a lot of studies have been done on building resting on sloping ground. Most of conclude in studies that the Buildings on the sloping ground will be affected more than the buildings on the flat ground and also the dynamic response of hill buildings will differ a lot from the plain ground buildings. While comparing the buildings on hilly areas and flat ground, hilly areas behave differently. These will show maximum storey displacement and storey drifts. High grade concrete and high strength steel are used to provide more strength to buildings. Shear walls, central core walls, bracings, outriggers are the structural resisting system also added to increase the strength of the building.

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